NEW EDUCATION DEVICES DEMONSTRATING THE FUNCTIONALITY POSSIBILITIES OF PHOTOCELLS

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ABSTRACT

This paper presents the results of experimental studies of new educational devices developed and created by us using the physical capabilities of solar cells. The developed educational devices allow students to understand the essence of physical phenomena occurring in solar cells.

Keywords: photocell, short circuit current, no-load voltage, absorption coefficient, multimeter.

INTRODUCTION

Using the unique capabilities of semiconductor photovoltaic cells to reveal the essence and demonstrate various physical effects is of great interest. On the one hand, it allows to develop and create a number of new educational devices with multifunctional capabilities for demonstrating physical phenomena. Conducting such experiments allows students to more fully understand the essence of physical phenomena occurring in solar cells. On the other hand, they show the prospects and possibilities of using solar cells in all branches of science and technology, as well as in educational institutions of technical profile [1,2].

The aim of this work is to create an educational laboratory device to demonstrate the possibility of using photocells in studying light absorption and obtaining new original information on the optical properties of various substances, as well as for testing them by students in practice as a result of laboratory work in studying the laws of optics and Booger’s law. (1).

METHODOLOGY

We have developed a fundamentally new educational laboratory device using a silicon photocell for schools, lyceums, colleges and higher educational institutions [3,4].

The main advantages of the developed educational laboratory device are:

- absolute safety at work, due to the lack of use of external electrical power.
- the versatility of such a device through the use of various solids with different thicknesses and colors, which allow students to understand the physical nature of the nature of the absorption of light in solids, as well as in the same device to perform dozens of different independent laboratory work with results not similar to each other .
- the device actively causes students to creative thinking and interest in the studied physical phenomenon, and also put it into practice.
- the device is reliable, transportable, with an interesting design, convenient for use, quite durable and not expensive.

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- the device simultaneously allows students to study the physical fundamentals, structure, and also the parameters of the photocells and its functionality.

RESULTS

On the picture. Figure 1 shows the appearance of a device that will study and evaluate the ability of light absorption and the absorption coefficient of various solids, as well as get acquainted with the structure, principle of operation and parameters of photocells.

Picture. 1 Appearance of a device for studying light absorption.

In general, the created device consists of a silicon photocell placed in a case, a micromultimeter that allows you to measure such basic fundamental parameters as I_{shc} - short circuit current and V_{oc} - open circuit voltage of the photocell, both in the absence and presence of various colored plastic plates on the photocell surface, which completely cover the surface of the photocell. These plates (each type of eight pieces) have the same shape, but different thicknesses from 3 to 1 mm.

Studying the absorption of light in various substances not only allows you to study the absorption of light in substances according to Booger's law, but also actively stimulates students' creative thinking to understand the nature of light absorption in substances and shows the possibility of using this interesting law of physics in practice.

Students independently selecting substances with different nature, thickness and color, can conduct various interesting experiments on the created device and solve various problems that are significantly different from each other. The possibility of combining and manipulating various objects eliminates the same results that exist with existing training devices. As a result of the experiment, students receive interesting new information about the optical properties of various substances.

Students of their choice can also independently choose other substances: film, paper, glass, fabric of various thicknesses and their different numbers. The following interesting laboratory work can be performed on the developed device:

1. At a constant light, without any objects, the value of the short circuit current (I^0_{shc}), which appears due to the absorption of light in the photocell (I^0), is determined. Under the same

lighting conditions, plates with different colors and with the same thickness (d=3mm) are placed on the surface of the photocell and the value of the short circuit current (I^{n}_{shc}) is measured ($I^{0}_{shc} - I^{n}_{shc}$) - it shows the light transmittance of each of the studied substances.

The ratio of the short circuit currents of the photocell ($I^{0}_{shc} / I^{n}_{shc}$), allows us to evaluate the light absorption capacity of these plates relative to each other depending on their color. Based on the data obtained, table 1 is filled.

Table 1. For example, the results of the study of plastic plates with the same thickness, but with different colors.

Table 1. The dependence of the short-circuit current on different colors in plastic plates with the same thickness.

Short circuit current	In the absence of filter	Green filter	Yellow filter	Blue filter	Red filter
I_{shc}	54,2	14,4	21,4	5,8	32,1
$I^{0}_{shc} - I^{n}_{shc}$	0	39,8	32,8	48,4	22,1
$I^{0}_{shc} / I^{n}_{shc}$	1	3,76	2,53	9,34	1,69

Pupils themselves can do the same using other materials. Obtaining the results allows students to understand the patterns of light absorption by various substances depending on their nature, structure, color, etc. By analyzing the results with the teacher, they can recognize the physical essence of the absorption of light in substances.

2. The second experiment is the study of Booger's law. In this case, first, in the absence of a substance I^{0}_{shc} on the surface of the photocell, it is measured, then several plates with the same thickness of a certain substance are successively placed on the surface of the photocell, and values are measured each time. The results are shown in table 2. As can be seen from the table with an increase in the number of plates, i.e. with increasing thickness of the substance, the value I^{0}_{shc} decreases. This confirms Booger's law:

$$I = I_0 \cdot e^{-\alpha d} \quad (1)$$

where, I_0 - is the initial light intensity, α - is the absorption coefficient, d - is the thickness of the substance.

From equation (1) we obtain the expression for the absorption coefficient

$$\alpha = \frac{1}{d} \ln \frac{I_0}{I} \quad (2)$$

Moreover, in our case, I_0 - is I_{shc}, $I = I^{n}_{shc}$. Based on the data obtained, we construct a graph ln ($I^{0}_{shc} / I^{n}_{shc}$) of q and determine the absorption coefficient of the test substance

Students can choose different substances with different thicknesses and can evaluate the absorption coefficient of a given substance. Table 2. shows the change in the I_{shc} depending on the thickness of the green plate.

Table 2. Changing the short-circuit current depending on the thickness of the green plate.

d-the thickness of the green plate [sm]	0	0.3	0.6	0.9	1.2
I_{shc} - short circuit current [$мA$]	14.4	6.3	3.5	1.7	0.82
I^0_{shc} / I^n_{shc}	1	2.28	4.11	8.47	17.56

3) The third work is the study of the parameters of the photocell, depending on the intensity of the incident light, since $I_{shc}(I)$ and V_{oc}. This experiment is carried out by controlling the distance between the photocell and the illuminating lamp. The obtained current dependences are shown in table 3 and from them it is possible to construct a graph of the dependence I_{shc}, where d is the distance between the photocell and the lamp.

Table 3. Dependence of the short-circuit current on the distance between the photocell and the lamp.

l – distance from the photocell to the lamp $[sm]$	5	10	15	20	30
I^0_{shc} – short circuit current [$мA$]	71.7	59.4	46.0	33.0	10.0

These results show that the fundamental ones depend substantially on the intensity of the illuminating light.

4) The fourth work is carried out as follows. With constant illumination of the photocell, the values of I^0_{shc} and V_{oc} are determined. Then, the surface of the photocell is closed with specially made cardboard paper. First $\frac{3}{4}$ part, then sequentially $\frac{1}{2}$ part, $\frac{1}{4}$ part, and $\frac{1}{8}$ part. The obtained values I^0_{shc} and V_{oc} are entered in table 4.

Table 4. The dependence of the short-circuit current and no-load voltage on the illuminated area of the photocell.

The illuminated area of photocell	100%	75%	50%	25%	12,5%
I_{shc} – short-circuit current [mA]	74.0	57.0	39.2	21.0	11.1
V_{oc} – the open-circuit voltage [mV]	31.0	30.7	30.3	30.2	30.1

DISCUSSION

As can be seen from the table, the value of I_{shc} decreases in proportion to the decrease in the surface of the photocell, and the value of V_{oc} is practically independent of the area of the photocell when illuminated with light. These data show that by increasing the area of the photocell, it is possible to control the value of the current e received from it, but at the same time, V_{oc} will remain constant. To control V_{oc} - it is necessary to increase the number of photocells. Thus, using the functionality of the photocell, you can conduct a very interesting variety of experiments.

CONCLUSION

Such experiments allow students not only to experimentally study and clearly demonstrate the laws of physics, which are practically impossible to show on the basis of existing educational devices, but also to study the principles of operation of the photocell and its basic parameters.

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